ANNUAL REPORT FOR AWARD # 0218088

Submitted October 5, 2005

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Long-Term Ecological Research at the H.J. Andrews Experimental Forest (LTER5)

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Research Experience for Undergraduates: Jessica Mandrick; Sarah (Sunny) J Shaffar, Jessica Niederer; Doreen McIntosh. Aaron Wunnicke, Braden Burkholder

Pre-college teacher(s): Daniel Bregar, Lyn Neely; Jeffrey Mitchell

High school student(s): Aaron Pascoe; Nathan Patterson, Kathryn D Franklin; Russell G Harmon; Jake Hoyman; Colin M Sexton

Partner Organizations:

Forest Service Pacific NW Forest & Range Experiment Station: Financial Support; In-kind Support; Facilities; Collaborative Research; Personnel Exchanges

The Forest Service is a key partner in LTER research at the Andrews. They not only contribute financial support, but also personnel, and senior scientists. This LTER would not be able to function without this partner!!!

USDA, Forest Service: In-kind Support; Facilities; Collaborative Research
The management side of the Forest Service through the Willamette National Forest is actively engaged in research in and around the Andrews. Maintenance of roads and buildings is aided by their staff. Long-term experiments are installed and protected with their help and landscape-level studies and application of research results are only possible with their collaboration.

USGS Water Resources: In-kind Support; Collaborative Research
The USGS has designated Lookout Creek as a Benchmark site. USGS will analyze water samples collected from the base of the watershed draining the Andrews.

USGS Biological Resources: Collaborative Research
USGS Biological Resources is collaborating on biogeochemical studies at the Andrews.

Activities and findings:

Research and Education Activities:

General Overview
The Andrews LTER program seeks to understand the long-term dynamics of forest and river ecosystems of the Pacific Northwest. The Central Question guiding Andrews LTER research is: How do land use, natural disturbances, and climate change affect three key sets of ecosystem services: carbon and nutrient dynamics, biodiversity, and hydrology? These processes and ecosystem services represent scientifically and socially important, tractable variables, and their responses are posited to represent different classes of ecosystem behavior at the landscape scale. Climate, land use, and natural disturbances are the major drivers of change in the Pacific Northwest region. The approach being used to address this question is multi-faceted involving retrospective analysis, time series observations, experiments, and use of simulation models for
synthesis, extrapolation in time, and interpolation in space. The principal spatial scale of inference for LTER studies is the Andrews Forest and adjacent upper Blue River watershed, an area of 16,000 ha. The principal temporal extent of ongoing LTER studies spans the past 500 years and to several centuries projected into the future.

Essential long-term studies are being continued and others added to increase spatial and temporal overlap of scales. The standard 5 LTER core activities are being addressed by work in seven component areas: (1) climate, (2) hydrology, (3) disturbance, (4) ecophysiology, (5) carbon and nutrient dynamics, (6) biodiversity, and (7) stream-forest interactions. In this grant cycle, studies continue to examine the interaction of the drivers of change and responding processes and taxa, but the conceptual emphasis is on temporal behavior, its causes, and its consequences for ecosystem change. We are examining temporal behavior over time scales of days to hundreds of years focusing on: (1) modulation, (2) temporal lags, (3) spatial coherence, (4) path dependence, (5) hysteresis, and (6) alternative stable states. Exploring these aspects of temporal behavior are helping to address the Central Question by quantifying natural temporal variability and providing insights into mechanisms that control processes. Another focus of synthesis is small watersheds, an important landscape unit providing opportunity for integration of climatic, ecosystem, and hydrological processes as well as knowledge of temporal and spatial scaling. Past experiments, long term records of climate, stream flow, nutrient exports, and vegetation change, as well as modeling are enhancing this integration effort.

Specific Areas of Activity
General Site Activities.
In the third year of the fifth increment of LTER funding for the Andrews Forest program (hereafter referred to as LTER5) we have continued to emphasize development of our synthesis projects. We held our seventh annual Andrews LTER symposium in January 2005, an event that attracted over 75 participants. The focal topic was lessons from our present and past synthesis areas including temporal behaviors, small watersheds, and landscape dynamics. We also organized a symposium along similar lines for the Northwest Science Meeting held in Corvallis in March 2005. The 16th annual HJA DAZE was held in June 2005; this remains an important event for new students, postdoctoral fellows, visiting scientists, administrators, and resource managers to learn about our LTER and related activities. Approximately 100 individuals attended the event.

Preparation for our mid-term review was a major focus of our work this year. In addition to preparing presentations of our science, we underwent a major effort to compile statistics on participants at all levels, projects, related grant activities, and other items. Our plan is to create more formal databases that are more frequently updated. Although this will be a challenge, we believe this is the best way to keep this information current.

Intersite Activities.
Intersite activities have continued to be major areas for our LTER. Drs. Gregory and Johnson and Ms. Ashkenas have continued to participate in the LINX-2 project. Dr. Lajtha is starting collaboration with Dr. Jill Baron to examine responses of watersheds to increased inputs of N and S. We are preparing the input data required by this modeling exercise and the actual analysis should begin winter of 2006. Dr. Harmon continues to coordinate the LIDET project, a long-
term effort to examine long-term decomposition dynamics of litter. Two NCEAS working groups have met with two more meetings scheduled over the next year to accomplish this task. Drafts of 5 manuscripts are scheduled to be completed fall 2005. Field-work supported by an intersite collaborative supplement to measure carbon balances of two old-growth forests in the T. T. Munger Natural Area in Washington State and Fraser Experimental Forest has been completed. A preliminary calculation of the changes in live biomass has been completed as well. A manuscript will be written over the next year in collaboration with Dr. Ryan of the Rocky Mountain Research Station to summarize the results.

Our participants have been involved in numerous activities to strengthen the LTER Network. Dr. Bond participated in a Congressional briefing on the topic of application of LTER-related research. Dr. Harmon presented results from our Temporal Behaviors Synthesis Area at the 2005 ESA meeting as part of a symposium on LTER research. The lead site Information Manager (Henshaw) continues to be active in Network-level activities and serves on the IM Executive Committee, the LTER Coordinating Committee, and chairs the NIS Advisory Committee. Andrews personnel Harmon and Henshaw played key roles on the LTER Network Information System Advisory Committee in drafting a strategy to support synthetic research efforts at the LTER Network level. The spatial data manager (Valentine) continues to be involved in collaboration with other LTER sites and the Network Office in developing standards for spatial data and Internet mapping web services.

Our participants have also been involved in several national planning efforts related, in part, to LTER. Harmon and Henshaw have attended 3 meetings related to the LTER Network Synthesis Planning. Drs. Bond, Lajtha, and Swanson have attended the NEON planning efforts, and Harmon has represented the Pacific Northwest region in COREO workshops held in parallel to NEON planning.

The first LTER Graduate Student Collaborative Research Symposium was held on April 13th through the 17th at H. J. Andrews LTER. Our graduate student representatives (Sobota and van Huysen) played a major role in coordinating the local arrangements. This symposium was created in order to facilitate future graduate student interaction and participation in the broader community of LTER scientists, as well as to stimulate graduate student engagement in comparative and collaborative research efforts. There were a total of 66 graduate students representing 24 United States LTER sites and 11 students from international LTER sites (representing China, Mongolia, South Africa, Austria, Czech Republic, Brazil, Mexico and Switzerland). There were also 2 invited speakers (Dr. Whendee Silver and Dr. Scott Collins), 2 post-docs, 1 undergraduate, and multiple LTER information managers in attendance. Overall, there were 71 presentations (including LTER site review presentations and personal research presentations) and 13 training and collaborative workshops. The workshops, in addition to being very informative, also sparked at least five long-term cross-site collaborations. These collaborations are using long-term datasets that are available from LTER sites and will be used for cross-site comparison and will likely appear in peer-reviewed publications.

**ILTER Activities.**

Our site continues to be involved in many ILTER activities, including links with Australia, Argentina, Canada, Chile, China, Hungary, Japan, Mexico, New Zealand, Poland, Romania,
Russia, South Africa, and Taiwan. Specifically, Drs. Harmon, Chen and Perakis are collaborating with colleagues in Taiwan on a fine root decomposition study funded via the International Program. Harmon presented a talk on intersite decomposition experiments at this year's ESA meeting, and will reprise this at the upcoming ILTER meeting in Colima, Mexico. Dr. Lajtha has continued to develop a network of long-term soil experiments (the so-called DIRT project) involving manipulation of the inputs of above- and belowground detritus. She and Dr. Bond are working on supplement activities that involve both Hungary and Argentina. Dr. Lajtha's collaboration with Hungarian colleagues is an extension of a multi-site DIRT (Detritus Input and Removal Treatments) project, to assess how rates and sources of plant inputs control the accumulation and dynamics of SOM and nutrients in forest soils over decadal time scales. Dr. Bond is working with colleagues in Argentina and Chile to encourage development of one or more ILTER sites in that region. As part of an international ecology meeting in Mendoza, Argentina, she co-organized a symposium that focused on opportunities for research collaborations to compare ecological processes in similar latitudes in the western parts of North and South America. The symposium was attended by at least 30 scientists from Argentina and Chile, including several senior scientists who were invited specifically because of their interests and experience in long term ecological studies. A follow up meeting that will involve about 15 key people is planned for Andrews forest in May, 2006. Dr. Swanson continues to collaborate with scientists in Japan on a wide range of geomorphic, riparian and stream management. Drs. Harmon and Krankina are currently gathering chapters for a book to be published by Springer-Verlag that compares the carbon dynamics of the Pacific Northwest and northwest Russia. Drs. Miller, Moldenke and Luh, have starting planning collaborations on insect biodiversity, and lepidotterans specifically with scientists in Taiwan, Korea, and Japan.

**Project Administration.**

Dr. Harmon continued to serve as lead PI in the last year, although Dr. Bond will take over this responsibility in January 2006. The Executive Committee now consists of Drs. Harmon, Bond, Johnson, Jones, O'Connell, and Swanson. We have also continued the system of working committees to plan work activities for our Component and Synthesis Areas activities. This structure also allows all PIs to develop the leadership skills required for long-term management of our LTER. A major success was to secure administrative support for our LTER from OSU College of Forestry. This has allowed us to hire a professional level coordinator (DiGregorio) that will assist in organizing meetings, submitting proposals, tracking key administrative databases, and other important tasks. We were also successful in replacing the Site Manager (a PNW Research Station funded position) that became open with a recent retirement. The new Site Manager (Keable) is working closely with Dr. O'Connell on administering the site and also creating closer ties with the local school district.

**Informatics Activities.**

Information Managers at the Andrews Experimental Forest spent much of the year preparing for the mid-term review, and ultimately our site was credited as 'an exemplar of information management'. Descriptions of our information system are online: http://www.fsl.orst.edu/lter/research/component/infomgt.cfm?topnav=63.

Henshaw (USFS PNW) has been heavily involved with cross-site synthesis and network-level efforts and helped produce a data access policy for the LTER network (Brunt et al. 2004). Gody
Spycher (OSU), our LTER-funded IM person, will retire within the next year and Suzanne Remillard (OSU) will replace him. She also will continue as the database administrator for the LTER ClimDB/HydroDB intersite database. Theresa Valentine (USFS PNW) has received seed money from Forest Service R&D to develop WatershedDB, a collection of spatial data for HydroDB sites including research area and watershed boundaries, gaging station locations, and stream networks. The site also published a new, updated Andrews Experimental Forest map (http://www.fsl.orst.edu/lter/about/site/map.cfm?topnav=157) aided greatly by the IM teams leadership.

We currently have 130 databases including spatial databases online and available with complete metadata. This includes over 500 data tables with over 100 tables updated and 10 new databases added this year. Our metadata database now dynamically generates Ecological Metadata Language (EML), and also produces downloadable Adobe PDF files for each study database. We are now contributing EML to the LTER central catalog (Metacat) through dynamic database harvests.

Information managers have developed a new reservation system for the Andrews field station. This system enables the tracking of users, allows for the management of billing guests, and provides an online reservation request form.

The entire Andrews compound is now WiFi enabled and supports spread spectrum telemetry. Fred Bierlmaier, the on-site Andrews system administrator, recently installed the wireless local area network (LAN) which links the dormitories, cafeteria, shop, and director's residence to the existing LAN and internet. Wireless access points were installed in the conference hall and throughout most of the compound, and access points are planned for the classroom and library. A telemetry system based on 900 megahertz spread spectrum radios was installed to access data coming from data loggers on Watershed 1.

*Schoolyard LTER Activities.*

About half a dozen programs for grades K-12 use the Andrews Forest in a substantial way--most notable are the teachers' program funded by NSF through Portland State University and the more than decade-old SMILE program at Oregon State University. Our main collaborator for Schoolyard LTER is the SMILE program which helps Hispanic, Native American, and other minority students learn science, math, and health in K-16. We designed and are implementing an inter-school decomposition experiment. The goal is to provide experience observing an ecological process (decomposition) and to provide a common dataset for schools to compare. This activity follows an initial inter-school experiment on daffodil phenology, which is now in its second year. This initial activity demonstrated the need of coordination and common protocols to teachers. Through additional supplemental funding we are building closer ties with the school district closest to the H. J. Andrews Experimental Forest. We hope to host teacher workshops and students over the upcoming year. We also will be helping to host GIS Day on the OSU campus over the next year. Although many of our technical staff members have been participating in this activity for many years, supplemental funding will allow us to expand the number of students that can attend.
**Findings:**
Component Areas.

*Climate:* Continued measurement of climatic variables is a major field activity for our site. Analysis of these data by Dr. Daly has concentrated on gaining better insight into the patterns and spatial scales of cold air drainage in the HJ Andrews Experimental Forest, and how it may affect the thermal climate of the region at various temporal scales. This analysis is also a key facet of our temporal behaviors synthesis area; given that abiotic drivers such as temperature have profound effects on ecosystem function, this work has great implications for understanding the degree of synchrony at which ecosystem processes operate at the Andrews Forest, and in other areas with significant topography. Our hypothesis is that the thermal behavior of a site is dictated by its topographic position (convex slope, concave slope, ridge top, valley bottom, etc), but that this needs to be evaluated at a series of scales, from the mesoscale (>50 km) to the microscale (< 10 m). What we do not know at this point is the relative contribution of the topographic position at each scale to the resultant thermal behavior. Therefore, temperature measurement transects previously placed across the Lookout Creek drainage (larger scale) were recently augmented by smaller transects across two tributary drainages (smaller scale). Early data analysis suggests that sites on different topographic positions possess different average temperature regimes and also have very divergent temporal signatures at time scales of a month or longer. It may be that sites with different topographic positions are either subject to different thermal forcing factors or respond differently to the same forcing factors.

In LTER5, we are also examining century scale climate and coupling with vegetation. Dendrochronological information from a previous master chronology for the Andrews (developed by Peter Brown in 1996) was combined with new dendrochronology information interpreted by Danielle Robbins (MS, Forest Resources) from a set of trees aged 600 to 800 yrs (Giglia 2004) in the central western Cascades. The new master chronology was compiled and preliminary analysis was completed by Bryan Black (Research Assistant Professor, Hatfield Marine Science Center). Black’s analysis showed that there is strong positive correlation between tree ring width (corrected for competition) and the Palmer drought severity index (PDSI) in the current and previous summer months. Negative values of PDSI indicate drought, so growth rates in trees aged up to 800 yrs in and around the Andrews Forest respond positively to extra moisture during summer months. This pattern contrasts with that of forests on the east side of the Cascades whose growth is linked to variations in winter precipitation (Knapp et al 2002). Bryan Black and Sara Shafer (USGS Biological Resources Division) are pursuing these ideas in a proposal to NOAA.

*Disturbance.* We continue our disturbance history and landscape management studies for a 400 km² area centered on the Andrews Forest. A new Ecoinformatics IGERT PhD student, Alan Tepley, is beginning study of how fire regimes vary across terrain in three different western Oregon landscapes, including the Andrews Forest area. Implementation and monitoring of the Blue River Landscape Study in the area adjacent to the Andrews Forest continues. A synthesis of using historic disturbance regimes to guide management of forest landscapes is now underway (Cissel et al. 1999).
The 1980 eruption of Mount St. Helens corresponded with the inception of the Andrews Forest LTER program and there has been strong interplay of ecological work and workers at Mount St. Helens and Andrews LTER ever since. Major syntheses of the 25 years of ecological development at Mount St. Helens appeared in 2005 (Dale et al. 2005a,b). Central features of the work at these two places include recognition of the importance of biological legacies after most disturbances and the strong and continuing interactions between physical and biological processes during and after severe disturbances.

Biodiversity. Dr. Miller is examining how plant-feeding Lepidoptera and Coleoptera are distributed across the Andrews watershed in time and space. He is now analyzing data from studies that have sampled adult Lepidoptera using UV blacklights, from May through October for the 1994-2005 period. The 2004 sampling effort added another 20 species to the inventory list of the Andrews Macro-Lepidoptera species, bringing the total to 526 species. The new species are those typical of eastern Oregon ecological zones; high elevation locations; and exotic locations. These findings represent the highest number of additions to the Lepidoptera database since 1996. The presence of eastern Oregon species suggests that the 2004 season was different in climate pattern (which it was) and may be part of a general pattern for species turnover (based on documentation of new resident species) reflecting longer-term climatic changes. More detailed analysis of the entire dataset will confirm the latter point, which could be a major finding. The exotic species story is compelling as well. Three of the new species are of exotic origin and one of the species is already widespread throughout the Andrews watershed. All three species were known to be in Oregon, but this is the first documentation of their presence in the Andrews Experimental Forest. At this time we do not see any of these exotic species posing a “pest threat”. Spatial variation has been examined using more recently collected data. In 2004-2005 twenty sites were sampled every other week and located to compare species richness, abundance, and functional group composition among riparian, upland, closed canopy and open habitats. To date the results show: 1) species richness was higher in the riparian habitats relative to the upland habitats. Thus, the original working hypothesis that upland habitats exhibit a higher degree of species richness and abundance based on the known food-plant relationships for caterpillars is not supported. Previous studies on food-plant relationships showed that plant species in the upland vegetation communities supported a higher number of Lepidoptera species and might therefore be a “hotter” spot for biodiversity. 2) Similarly, species richness was higher in open habitats (meadows) relative to sites characterized by a closed overstory (mature dense forest). Thus, the working hypothesis that closed forests have higher richness than open areas is not supported either. Previous studies on food-plant relationships showed that plant species in the understory of closed canopy forests supported a higher number of Lepidoptera species and might therefore be a “hotter” spot for biodiversity. 3) The data regarding abundance shows the opposite pattern to that of species richness.

A M.S. student (Frady) has been examining aquatic macroinvertebrate biodiversity by comparing instream community composition in old growth and second growth basin pairs at 3 sites in the Andrews, looking at seasonal differences in benthic species and emergent adults. Preliminary results indicate that biodiversity in streams in areas that were harvested 20-40 yrs ago is very similar to that in adjacent old growth streams (Frady et al 2005). Densities of benthic and emergent macroinvertebrates are also similar among basin pairs. There are strong seasonal
trends and densities and richness are greatest in summer. Among basin pairs, the mid-elevation sites have the highest abundances across seasons.

Dr. Halpern and an M.S. student (Jim Lutz) have completed a comprehensive analysis of changes in forest structure during early stand development with a focus on rates, causes, and consequences of tree mortality (Lutz 2005, Lutz and Halpern in review). Measurements of 193 permanent sample plots in WS1 and 3 span more than two decades of observation (14-38 yr after disturbance), generating 75,126 data records and 7,146 tree deaths. As a cause of mortality, suppression was more than 2.5 times as common as mechanical damage (windthrow, stem snap, crushing). However, biomass lost to mechanical damage was nearly four times that lost to suppression, with mortality aggregated in both space and time. Although sprouting hardwoods experienced high rates of mortality, their biomass increased continuously as dominant stems achieved large sizes. Shade-tolerant conifers — typically assumed to play a minor role in early forest development — accounted for 26% of stems 38 yr after disturbance. Our long-term observations suggest that 1) current models of stand development oversimplify the processes by which young stands develop, and 2) gap-forming processes that contribute to structural complexity in old growth can also be active in young forests.

Dr. Jones and her graduate students have been examining spread of exotic plant species along road and stream systems. This analysis indicates that at the landscape scale water and sediment flow and its coupling to roads promotes exotic plant invasion. Studies using a conceptual model of stream network-road network linkages have shown that water and sediment flowpaths connected from roads to streams promote exotic plant invasion of stream channels from roads (Watterson 2004; Watterson and Jones, in press).

Hydrology. We are examining interannual trends in climate variables and streamflow at the annual to decadal time scales using long-term records from the Andrews and climate indices of ENSO (El Nino/Southern oscillation), PDO (Pacific Decadal Oscillation), and PDSI (Palmer drought severity index). Temperature and precipitation at the Andrews site are more strongly coupled to the El Nino/Southern Oscillation than any of 15 LTER sites examined by Greenland (2003). This coupling means that the Andrews climate has higher summer precipitation and warmer winter minimum temperatures in years with a strong El Nino signal; the Andrews also has warmer winter temperatures in years with a strong PDO (Pacific Decadal oscillation) signature. However, the ENSO signal effect on summer climate is not transmitted to streamflow because all additional summer precipitation is transpired by vegetation. Summer precipitation and evapotranspiration are well correlated (r²=0.99) at the Andrews, but these variables are not correlated at other forested LTER sites (Jones, unpublished data).
Comparative analysis of 50-yr records of stream flow from small watersheds at the Andrews, as well as at other small watersheds at USFS experimental forests in the Pacific Northwest, and at the Coweeta and Hubbard Brook LTER sites (using Hydro-DB) indicates that forest age, forest type (conifer vs. deciduous) and climate (xeric vs. mesic) influence responses of water yield to changes in vegetation (Jones and Post 2004). Because of the marine climate and winter precipitation, the Andrews forest experiences more dramatic seasonal variation in precipitation and streamflow than other northern temperate forest sites with comparable records (coastal redwoods at Caspar Creek Experimental Forest; eastern deciduous forest at Coweeta, Fernow and Hubbard Brook LTER sites). Old-growth conifer forests in the Andrews’ strongly seasonal climate respond quite differently to forest harvest than other forested LTER sites; after forest harvest the Andrews forest also experiences larger and more persistent changes in seasonal streamflow (increases in winter maximum flow and decreases in summer low flow) than other forested sites (Post and Jones 2004). Old-growth forests (longer times since last stand-replacing disturbance) and those with dry summers experienced more persistent winter increases in water yield after forest removal: possible mechanisms include interception and water storage in canopy epiphytes (Jones 2005). Conifer canopy interception storage is significantly augmented by the presence of the epiphyte community in old growth forests (Pypker 2004).

In LTER5 we are examining water residence times in hillslopes and the hyporheic zone. Studies of the routing and timing of water delivery and solute fluxes in hillslopes have shown that water retention times range from 6 months to 2 years (McGuire 2004, McGuire et al 2005; McGuire and McDonnell, in review). Hyporheic zone tracer experiments have revealed power law residence time distributions in channels with different character in small and large streams over various seasons (Anderson et al in press; Gooseff et al, in press a, in press b, in review; Ninneman 2005).

Ecophysiology. A new series of studies have been designed by Dr. Bond and colleagues to build upon past work on factors controlling transpiration of trees in the Andrews (Moore et al. 2004). We made great progress this year in establishment of infrastructure and baseline data for the eight “telemetry transect” plots arrayed along a ridge-to-ridge transect in WS1. Radio-telemetry is now functioning at all sites, and a steady stream of data is accessible at OSU from the field on a nearly real-time basis. We are currently working with Mike Bailey, professor of Computer Science at OSU, to organize a senior project for a group of Computer Science undergraduates to develop QA/QC software for the datastream this project produces. Three arrays of solar panels are now in place, providing enough power for sapflow at half of the sites (installed as of July 2005) and environmental monitoring at all sites. A total of 96 electronic soil moisture sensors have been installed, and we have completed a detailed analysis to calibrate and validate data from the sensors (Czarnomski 2005). We are also continuously measuring soil temperature and air temperature and humidity. Two undergraduates (Jess Mandrick, Swarthmore; Lisa Padilla, OSU) conducted independent studies during 2005 to determine whether we could use a Multifrequency Electromagnetic Profiler (Geophysical Survey Systems, Inc) to extend inferences of soil moisture from the sensors over a larger spatial grid. Unfortunately, procedure does not look promising, but it was an excellent student project. The students also measured structural characteristics of the eight plots, including LAI, basal area, sapwood basal area and annual growth. For more information see http://feel.forestry.oregonstate.edu/ecohydrology/default.aspx
Dr. Bond is also leading an effort to examine the flow of air in small basins in the Airshed Project. This has also been a very active project in 2004-2005. We have made major progress in infrastructure, including construction of a ridgetop tower, extension of a tower in the base of the watershed to 40m, and the development, construction and testing of an automated air sampler (see photo). A pump pulls air alternately from three heights on the tower and directs them through an infrared gas analyzer (top box in photo) for analysis of CO2 concentration, and then through one of a set of 16 stainless steel sampling loops (bottom box in photo) arrayed around a “Valco valve”. CO2 concentrations are monitored by a computer which controls the valve, opening and closing the sample loops sequentially to collect samples over a designated range of CO2 concentrations. After sample collection, the loops are taken to a mass spectrometry lab at OSU for analysis. We have also conducted extensive tests to validate the integrity of the laboratory analyses. The procedure is producing outstanding “Keeling Plots”. In an important new activity, we teamed with Dr. Brian Lamb’s group (Washington State University) to conduct an experimental release of the inert gas, SF6, to better characterize airflow patterns in Watershed 1. Initial analyses confirm suspicions of a strong advective transfer process in the watershed; more than 50% of the tracer gas, released more than 60 m upstream from the detector, was transported laterally in the air drainage system. We expect to submit at least two publications for this project in the coming year. For more information see http://feel.forestry.oregonstate.edu/airshed/default.aspx.

Carbon and Nitrogen Dynamics. Drs. Harmon and O’Connell are supervising a M.S. student (Woolley) who is examining annual variation in tree growth. Past efforts have focused on determining the adequate sample sizes needed to obtain a precise estimate of average annual growth. A model has been developed to apply growth rates to non-sampled trees to predict total stand volume and volume added per year. Results for six Douglas-fir dominated stands of varying age classes (old growth, mature, and young) was presented at this year’s ESA meeting. This analysis indicates that while there are good correlations between stands of similar age, correlations of annual growth rates between age classes (particularly young versus the mature and old-growth stands) can be very low and even negative. This indicates that response of tree growth to climate at the level of the entire Andrews Experimental Forest will be much lower than for individual stands.

As part of an effort to inventory the carbon and nutrient stores in the small watersheds in the H. J. Andrews we have completed measurements of coarse and fine woody detritus and forest floors in six of the eight small watersheds present on the forest (WS01, WS02, WS06, WS07, WS08, WS09, and WS10). Combined with an earlier effort to install vegetation plots in these same watersheds, these data allow us to compare the different ages and locations. A preliminary analysis shows a dramatic difference in stores of all aboveground pools between watersheds dominated by mature to old-growth forests (WS08 and WS09) versus those with young forests (WS06 and WS07) (Figure 1). In the next year we will sample the various pools, particularly the live ones, to determine nutrient concentrations.
Figure 1. Preliminary analysis of organic matter stores in all pools except mineral soil for four of the small watersheds in the H. J. Andrews Experimental Forest.

Long-term experiments on log, branch, and root decomposition have been continued. In summer 2005 a 10-year root decomposition experiment being conducted at Cascade Head, H. J. Andrews, and Pringle Fall Experimental Forests was completed. Analysis of the data will occur over the next year. Another notable event was the 20th anniversary sampling of the two log decomposition experiments that have been conducted at the H. J. Andrews. Logs from both the terrestrial-aquatic comparison and the upland 200-year study were sampled. Preliminary analysis of these results will begin next year, but it is already clear that decomposition rate constants of logs can vary by an order of magnitude, a difference largely caused by differences in the decay-resistance of heartwood for the different species. Harmon, Fasth and Sexton created a website where preliminary data on other log decomposition studies that have been conducted by the Andrews LTER are posted (http://www.fsl.orst.edu/lter/pubs/webdocs/reports/decomp/cwd_decomp_web.htm). This analysis indicates results from the H. J. Andrews Experimental Forest span the observed range for the rest of the western USA. While the response of log decomposition to temperature can be seen, it is also clear that moisture is interacting strongly with temperature. This analysis also confirms that logs of the genus *Abies* tend to decompose at twice the rate of those of *Tsuga* (Figure 2). We hypothesize this is due to the species of decomposer organism (i.e., brown-versus white-rot systems). In addition to providing insights in the controls on this process, this report provides a hard-to-get parameter for fire fuel models.
DIRT (Detritus Input and Removal Treatments) is assessing how rates and sources of plant inputs control accumulation and dynamics of soil organic matter (SOM) and nutrients in forest soils. Established in 1997 using USDA funding, plant litter inputs have been manipulated at the DIRT plots in the H.J. Andrews Experimental Forest in Oregon for 8 years. Funding to maintain the treatments is partially provided by the Andrews LTER. Preliminary results from the study were published by Sulzman et al. (2005). Annual soil efflux from control plots ranged from 727 g C m\(^{-2}\) y\(^{-1}\) in 2002 to 841 g C m\(^{-2}\) y\(^{-1}\) in 2003. Aboveground litter inputs (149.6 g C m\(^{-2}\) y\(^{-1}\)) and differences in soil CO\(_2\) effluxes among treatment plots were used to calculate contributions to total soil efflux by roots and associated rhizosphere organisms and by heterotrophic decomposition of organic matter derived from aboveground and belowground litter. On average, root and rhizospheric respiration (R\(_r\)) contributed 23%; aboveground litter decomposition contributed 19%, and belowground litter decomposition contributed 58% to total soil CO\(_2\) efflux, respectively. These values fall within the range of values reported elsewhere, although our estimate of belowground litter contribution is higher than many published estimates, which we argue is a reflection of the high degree of mycorrhizal association and low nutrient status of this ecosystem. Additionally, we found that measured fluxes from plots with doubled needle litter led to an additional 186 g C m\(^{-2}\) y\(^{-1}\) beyond that expected based on the amount of additional carbon added; this represents a priming effect of 187%, or a 34% increase in the total carbon flux from the plots. This finding has strong implications for soil C storage, showing that it is inaccurate to assume that increases in net primary productivity will translate simply and directly into additional belowground storage.

![Figure 2. Decomposition rate constants for logs in the western USA.](image_url)
Stream-Forest Interactions. Wood sampling continued in a 1-km reach of Mack Creek to examine retention and transport of large wood by streams. Wood movement using tagged wood in an additional 16 streams through a range of vegetation types and harvest histories in McKenzie Basin has been monitored now for over 5 years. Drs. Jones and Swanson have been examining the current distribution of wood in streams in and near the Andrews Forest. This work indicates that forest patches created along roads adjacent to streams have locally reduced wood inventory in streams over periods up to 50 years since forest harvest (Czarnomski 2003; Dreher 2004; Czarnomski et al in review).

Fish population sampling continued in Mack and NF Quartz Creeks. Long-term dynamics of cutthroat trout populations have been examined in Mack Creek from 1973 to the present (continuous since 1986; gaps prior to 1986). This represents one of the longest records of fish populations (or any aquatic population) in the western United States. This study documents the natural variation in fish densities and community structure in a stream through an old growth forest as well as fish response to vegetation recovery in a harvested reach. This long-term record has been re-worked so that synthesis and analyses of temporal dynamics will be possible.

Dr. Johnson is studying how the flushing of dissolved organic carbon (DOC) in response to storm events may be indicative of DOC pools contributing to runoff. Hood et al. (in revision) assessed how the quantity and quality, both chemical and spectroscopic, of DOC changed in response to a six day storm event during the wet season of 2003 in three small (<1 km²) basins: one old-growth watershed (WS02) and two previously logged watersheds (WS01 and WS10). Pre-storm concentrations of DOC ranged from 1.5 to 2.2 mg C L⁻¹ in the three watersheds and increased approximately three-fold on the ascending limb of the storm hydrograph. Initial and stormflow concentrations of DOC were both highest in the unharvested, old-growth watershed. The flushing of dissolved organic carbon (DOC) in response to storm events may be indicative of DOC pools contributing to runoff. Hood et al. therefore assessed how the quantity and quality, both chemical and spectroscopic, of DOC changed in response to a six day storm event during the wet season of 2003 in the watersheds. The specific UV absorbance (SUVA, 254 nm) of DOC in the three watersheds increased with rising DOC concentrations during the storm, suggesting that the DOC mobilized from catchment soils during storms is more aromatic than stream DOC during baseflow. The increase in SUVA ranged from 8 to 36% and was most pronounced in the catchments that had been previously harvested. Chromatographic fractionation of DOC similarly showed that there was a shift in the chemical character of DOC during the storm, with the percentage of DOC composed of non-humic material decreasing by 9-22% from pre-storm conditions and then rebounding after the conclusion of the storm. Fluorescence properties of DOC during the storm event suggest that there is not a pronounced shift in the relative proportion of streamwater DOC derived from allochthonous versus autochthonous precursor material, but that there is an inverse relationship between DOC concentration and Fluorescence Index in the harvested watersheds.
Figure 3 (Hood et al. in revision for Journal of Geophysical Research – Biogeosciences). Time series of specific UV absorbance (SUVA, 254 nm) of DOC, DOC concentration, and discharge in A) Watershed 1, B) Watershed 2, and C) Watershed 10. SUVA increases with the increase in discharge and DOC concentration in all three watersheds.
The LINXII group is examining the fate of nitrate in Mack Creek this summer, using $^{15}$N as a tracer. Dan Sobota is starting a dissertation to examine rates and mechanisms of nitrate retention by wood in streams as part of the LINX $^{15}$N project. LINX II release of 15N-NO$_3$ occurred in Mack Creek in September 2004 and most of the nitrate was transported downstream. Very little denitrification was observed in any of the Oregon sites. At Mack Creek, a stream through an old growth forest, approximately 2-4% of the tracer addition was taken up within the stream, primarily by mosses and biofilm, and another 3-4% was denitrified in the combination of stream and hyporheic zone (hyporheic research by Haggerty et al.). The agricultural reach in Camp Creek, a tributary of the McKenzie had similar uptake. The urban channel, Amazon Creek in Eugene, was concrete so there was no hyporheic exchange, and was covered by algae but had only slightly greater instream uptake and no denitrification.

**Synthesis Areas**

**Small Watersheds.** The ultimate goal of the small watershed synthesis area in LTER5 is to develop a synthetic understanding of the multiple controls on storage, transformation and losses of N on the small basin scale, taking into account different spatial domains (hillslope, riparian areas, streams), biophysical controls within each spatial domain, and connections among those domains. This year we focused on three aspects of the overall goal, 1) developing the conceptual organization for a process level model that links our current understanding, from different disciplinary perspectives, of processes that affect N dynamics, 2) analyzing long-term records of N inputs and outputs that will ultimately be used to test and calibrate the model, and 3) developing entirely new concepts about small basins that link the roles of watersheds, airsheds and carbon sheds over a common spatial domain. This synthesis area was managed by Jones, and modeling work was undertaken by K. Vache (postdoc). Synthesis participants included Ashkenas, Bond, Gregory, Haggerty, Halpern, Harmon, Johnson, Lajtha, McDonnell, O'Connell, Perakis, Sulzman, Swanson, and Wondzell. Specific activities within this synthesis area were:

1. **Creation of the conceptual linkages for a process model (using Stella) that combines N cycling mechanisms in the various components of small watersheds.** This prototype model includes modules representing N processes in canopies, soils, hillslopes, riparian zones, and streams. The knowledge represented in the model is based on experiments conducted at the Andrews (mostly during LTER5) supplemented by material from existing models, especially for the forest canopy components. The model includes 1) vegetation uptake on hillslopes; 2) soil microbial immobilization and release; 3) slow water flowpaths in deep soils on hillslopes; 4) biotic uptake in streams on epilithon or epixylon; 5) instream microbial uptake and release; and 6) storage along hyporheic flowpaths. The model was created to allow testing of simple hypotheses about interactions among mechanisms governing N retention in small watersheds.

2. **Analysis of 35-yr records of nitrogen inputs and outputs from 6 small watersheds at the Andrews.** Major findings include: long-term inputs of N have averaged about 2.5 kg/ha/yr, with no distinct trends since 1968; long-term outputs of N have averaged about 0.8 kg/ha/yr, with no distinct trends since 1968; inputs peak in late summer under very dry conditions, outputs peak about 5 months later, in mid-winter, during the peak seasonal discharge; N outputs have been quite insensitive to major perturbations, including 100% clearcut and burn, but quite sensitive to other perturbations such as soil freezing, debris flows affecting only the stream channel, or killing of a few trees.
3. Documentation of a conceptual model linking water, air flow, carbon, and nitrogen cycles in small watersheds. We aim to draft a manuscript with a working title, “Watersheds, airsheds, carbonsheds, nitrogensheds superimposed” to conceptually integrate the various strands of research ongoing in small watersheds at the Andrews.

Temporal Analysis. Field studies on climate, hydrology, tree growth, and fish populations that feed into our analysis of temporal behaviors are continuing and described above. Over the past year we have particularly focused on spatial coherence, presenting results at our annual symposium, the 2005 Northwest Science Meeting, and the 2005 ESA meeting. Our plan is to continue analysis of these individual studies over the next year and then to synthesize results into a BioScience review. We have made significant progress in examining the hypothesis that abiotic variables have greater spatial coherence than chemical or biotic variables. While our analysis supports this trend, it became clear that chemical variables can have high coherence when they involve primarily abiotic processes (e.g., Ca) or have very low coherence when they are involved in biological limitations (e.g., N). We have also revisited the initial hypothesis after observing that the degree of coherence is dependent on the time step of the analysis. We now hypothesize that for abiotic variables, spatial coherence increases as the time step increases. However, for biotic variables we expect the opposite trend as physiologically controlled processes become more important. We expect that at short-enough time steps (minutes to days) the coherence of biological variables should converge on that of the abiotic drivers (Figure 4).

![Figure 4. The hypothesized differences in coherence as a function of time step for abiotic versus biotic variables.](image-url)
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Sobota, Dan. Nitrate retention and transformation in Oak Creek: differences among forested, agricultural, and urban settings. Presentation at Monday Morning Stream Team Seminar, February 2005, Oregon State University, Corvallis, OR.


Training and Development:

We have continued to involve graduate and undergraduate students in our research activities. We are particularly involved in graduate student training via the classroom, on thesis and dissertation projects (14 completed this year), as well as activities that broaden the experiences of these students. We have offered opportunities for students to present their research findings to their peers and more senior colleagues via our annual symposium, by participation in H. A. J. DAZE (one day field trip held annually), sponsoring travel to meetings, and involvement in international exchanges. We have incorporated undergraduates into our program largely by supporting laboratory assistant positions, but also via REU experiences.

Outreach Activities:

We have used our standard approaches to outreach over the past year: field tours for students, media, public, and public officials; hosting large meetings, such as the LTER Intersite Graduate Students meeting and a conference for land managers on use of historic landscape dynamics in managing future landscapes. Several articles appeared in the regional press, such as an article on Harmon's log decomposition experiment and one on Jerry Franklin's receipt of the Heinz Award for his work on old growth and its roots in the Andrews Forest. In the past year we made substantial progress in development of the Long-Term Ecological Reflections program, a collaboration with the nature writer community through the Spring Creek Project for Ideas, Nature, and the Written Word, based in the Philosophy Department at OSU. The writers-in-residence program at the Andrews Forest continues (two residencies per year) and resulted in the first written product – Pyle's (2004) essay on the importance of taking the long view in studying and understanding these ecosystems (the NSF Director quoted from this essay in a major speech to characterize NSF's commitment to taking the long view in environmental research). A Long-Term Ecological Reflections field trip and panel for the Association for Study of Literature and Environment Annual Meeting in Eugene were quite successful and formed the basis for a regional National Public Radio show on the program. We also now display material on the program, such as the 'data' from the writers in the form of their journal entries while reflecting in the Forest, on the Andrews Forest webpage alongside our biophysical data. We have communicated with other LTER sites interested in developing similar programs.

An important area of outreach for Andrews LTER has continued through strong links with land management. LTER scientists have worked with manager colleagues to develop concepts for using information on historic disturbance regimes and range of historic ecosystem conditions in planning landscape management over the next few centuries. Much of this collaboration occurs via the Central Cascade Adaptive Management Partners committee. Andrews LTER scientists continue to be very involved in providing input to policy makers and the public on matters related to natural resource management and protection at state, regional, and national levels. We are participating in an intersite study of how we communicate results of our ecosystem science and what the impacts of those communications have been. This effort is funded via NSF and headed by Drs. Schindler and Lach.
Journal Publications:

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Internet Dissemination:

http://www.fsl.orst.edu/lter/index.cfm

This is the main HJ Andrews Experimental Forest website which is used to disseminate data and information about projects and research at the forest.

Contributions:

Contributions within Discipline:

Aside from our continued examination of ecosystem and ecological processes over the long-term (which is a general major contribution as it forms the empirical basis for several disciplines) our LTER is contributing to major conceptual developments in ecology and ecosystems. Specifically, by examining processes over broad-scales our LTER has contributed to scaling of small-scale measurements to very large areas. Moreover, our past work on the effects of land-use change on carbon stores in ecosystems has now become a major feature of this research area. This is a major shift in a discipline that was dominated by physiological level process models only a decade ago. Our new emphasis on temporal analysis is likely to make a major contribution because it will address major issues in temporal scaling of shorter-term results.

Contributions to Other Disciplines:

The presence of the LTER program has been critical in forming linkages with social sciences, computer sciences, and mathematics. For all these disciplines the databases, expertise, and problems being developed and examined by the LTER form a very attractive foundation from which to build these new collaborations. In terms of computer sciences and mathematics, the LTER was the centerpiece of a successful IGERT proposal on Ecosystem Informatics.

Contributions to Education and Human Resources:

We will have had at least 14 graduate students complete their degrees in the third year of funding of LTER5.

The Andrews Experimental Forest is a focal point for the Ecosystem Informatics IGERT that was awarded to OSU. In addition to providing test cases for research into this area, the Andrews hosted 'Boot Camps' in September of 2004 and 2005. This IGERT is being coordinated by Julia Jones, one of the LTER PI's.

A range of classes uses the Andrews LTER site and databases, a notable example this year being The Hydrological Sciences group from Lancaster, England.

By the end of 2005 we will have supported 3 teachers via RET supplements. This has provided experiences and data for these teachers to improve their instructional materials, including use of GIS, graphics and illustrations.
Contributions to Resources for Research and Education:
We have installed wireless receivers for the entire H. J. Andrews Headquaters complex in the last year. We have started, but not completed, a project to create PDF copies of all Andrews-related publications using supplemental funding. We have been placing recent publications that have come in PDF format on our website. Our goal is to have all Andrews-related publications internet accessible in the next few years. We also will begin the process of scanning our past information on site management, reviews, proposals, etc and creating an electronic archive. While this might have minimal direct science value, it does have historical value, and in fact earlier IPB era papers have become the grist for a Masters thesis.

We have reorganized our Website so it can be searched in a flexible manner by those wishing to find out about our site, our data, or our research program. The Andrews has restructured its metadata database for compliance with the Ecological Metadata Language (EML), and has implemented dynamic generation and delivery of EML files from its webpage. EML generation is considered essential for participation in future synthesis efforts. Andrews has been very involved in the development of the ClimDB/HydroDB project.

Contributions Beyond Science and Engineering:
Our outreach activities result in many contributions that have influence beyond science and engineering. Our collaborations with other agencies within the region have strongly influenced the way forests and streams are managed within the PNW.

Our site is also contributing to education in many forms, all of which helps inform the general public about how ecosystems function, how they might be managed, and why they are important.